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METHOD OF REPAIRING A RAIL

BACKGROUND

CLAIM OF PRIORITY

[0001] This application claims priority from Provisional Patent application serial number 60/564,763 filed April 23, 2004 and PCT Patent application serial number PCT/US03/24741 filed August 8, 2003 which claims priority from Provisional Patent application serial number 60/402,184, filed August 9, 2002.

FIELD

[0002] The invention relates to a method of repairing a railroad rail having a defect in the top portion of the rail by creating a cutout and filling the cutout with an appropriate material, preferably a high carbon content weld material.

DESCRIPTION OF RELATED ART

[0003] Railroads have to maintain their track to ensure safe operation of trains. Some of this maintenance is centered around the repair of rail defects. Railroad rails may be manufactured with internal defects or, as a result of wear-and-tear or fatigue, develop defects. These defects are found using non-destructive test methods. The Federal Railway Administration (FRA) mandates periodic ultrasonic testing of railroad rails to locate defects in the rail. When a defect is found, a temporary accommodation or a repair must be made to the track structure. Many of these defects are located in the top portion (i.e. the web or head) of the rail.

[0004] There are two common welding processes used to facilitate the repair of defects in railroad rails. They are the thermite welding process and the flash-butt

[0007] When a repair is accomplished by installing a rail plug, it is unlikely that the rail plug installed will be of the exact length necessary to maintain the ART of the rail. The ART of the rail is altered. As such, the installed segment will have a different ART than desired. The ART of the entire rail adjacent to the repair plug installation is changed. Management of the ART could be simplified if the rail was not severed during the repair of a defect.

[0008] A thermite weld can be used to weld the existing rail to a rail plug. A rail plug is cut to a length approximately two inches shorter than the length of the rail, containing the defect, which is being cut out. The rail ends to be welded are aligned. A sand mold is attached to both the existing rail and the rail plug around an approximate one-inch gap between the end of the existing rail and the end of the rail plug. The thermite charge is contained in a crucible immediately above the sand mold. After the mold is pre-heated, the thermite charge is ignited. The thermite charge creates molten steel which pours into the sand mold. As the molten steel solidifies, it forms a casting which bonds to, and is contiguous with, both the existing rail and the rail plug. In this manner, the rail plug is welded to the existing rail to form a continuous section.

[0009] The rail ends at the other end of the rail plug are aligned. A second thermite weld is made at an approximate one-inch gap at the opposite end of the rail plug, joining the rail plug to the existing rail. The area of the rail containing the thermite weld is not as strong as and is not of the same quality as a normal rail. Moreover, such welds are not clean as they can include numerous inclusions from the welding process. As such, the thermite welds typically require

[00011] The rail ends at the other end of the rail plug are aligned. The flash-butt welderhead is moved to the other end of the rail plug and clamped across the abutment of the rail plug and existing rail. The rail consumed during the production of the first flash-butt weld of the rail plug has created a gap at the location for the second weld. The rails are stretched to close the gap and the flash-butt weld cycle is carried out. The flash-butt weld consumes about one and one half inches of the rail at the second weld location. The rail is now returned to the pre-existing tensile condition. Rail anchors are placed onto the existing rail. The flash-butt welding process is typically more costly than a thermite process but produces a cleaner and stronger weld. However, this method also requires the repair crew to transport a plug to the rail repair site and the section of the rail containing the defect away from the site.

[00012] When rail plugs are installed using either the thermite or the flash-butt welding process, the rail is taken out of service. This prevents the railroad from running revenue producing trains. Thermite and flash-butt welding trucks need to occupy the track. The installation of a rail plug and resulting two welds uses valuable track time and needs to be kept at a minimum.

[00013] Joint Bar splices are, essentially, a reinforcing clamp applied to the rail to effect a temporary repair. A Joint Bar splice is used when there is not enough time to perform a complete repair or when other repair materials are not available. A Joint Bar splice, by government regulation, is a temporary repair and must be replaced within about 90 days. The Joint Bar splice reduces the operational limit of the rail in the repair area.

No. 5,877,868, No. 6,069,333, No. 6,166,347, No. 6,201,216, No. 6,207,920, No. 6,278,074 and No. 6,407,364. Using apparatus such as that taught in U.S. Patent No. 6,396,020 and U.S. Application Publication No. 2002-170,884 or U.S. Patent No. 5,605,283, strength variations across the weld fusion line are problematic.

[00018] Typical welding electrodes for joining material have a carbon content of 0.1% or less. While higher carbon content steel is known, forming that steel into welding electrode commercially is not accomplished.

[00019] Other prior art metal forming and treating techniques include drawing and annealing in a carburizing atmosphere although these procedures are not believed to have been used in combination in the production of welding electrode.

[00020] The metallurgical properties of welds generally have been discussed in a paper entitled "Effect of Carbon Content and Peritectic Reaction on Hot Cracking of Weld Metal of High Carbon Steel" authored by Koreaki Tamaki, Hiroshi Kawakami and Jippei Suzuki of the Department of Mechanical Engineering, Mie University, Kamihama-cho, Tsu, Mie, 514-8507, Japan. This paper provides general background.

[00021] Thus, it is desirable to provide a rail defect repair system that addresses above-identified issues and is acceptable to railroads for their use.

SUMMARY

[00022] The aforementioned issues can be addressed by solutions offered by the instant invention system. As more fully described below, the invention system or

formed in a generally tubular shape with the carbon present in the interior chamber defined by the walls of the tube. In terms of metal forming technique, generally a steel bar is grooved, the carbon deposited and the steel then drawn or otherwise formed around the deposited carbon.

[00026] As more fully detailed hereinafter, a weld system employed provides a clean weld, a weld as strong as the parent rail, has a small heat affected zone (HAZ), provides a good bond with the rail, does not exhibit hydrogen (H_2) embrittlement, deals with the issues of ART and CRT, and avoids transporting long sections of rail.

[00027] The system provides a rail repair which results in a rail having strength and quality comparable to the parent rail, but without consuming rail or causing carbon migration.

[00028] The system provides a rail repair which reduces the total number of welds in the remaining rail.

[00029] The system provides a rail repair which reduces the amount of materials and equipment that must be transported to and from the repair site.

[00030] The system provides a rail repair which does not require the repair weld to be aligned in order to complete the repair.

[00031] The system provides a rail repair which can be completed in less time than prior art repair methods.

[00032] The system eliminates the use of temporary Joint Bar splices.

[00033] The system enables the railroad to simplify the management of the ART.

[00044] Fig. 6 is a sectional view of a railroad rail with a welding mold fixture in place.

[00045] Fig. 7 is a side elevational view of a railroad rail with a welding mold fixture in place.

[00046] Fig. 8 is a graph showing hardness plotted against distance across a weld fusion line.

[00047] Fig. 9 is a flow chart showing the drawing, annealing and carburizing steps.

[00048] Fig. 10 is a schematic showing the composite weld electrode.

DETAILED DESCRIPTION

[00049] While the present disclosure will be described fully hereinafter with reference to the accompanying drawings, in which a particular embodiment is shown, it is to be understood at the outset that persons skilled in the art may modify the disclosure herein described while still achieving the desired result. Accordingly, the description that follows is to be understood as a broad informative disclosure directed to persons skilled in the appropriate art and not as limitations on the present disclosure.

[00050] A railroad rail 10 is typically formed having a base 12 with opposed flanges 14, 16, an upstanding web 18 extending upward from the base 12 between the flanges 14, 16 and a head 20 at the top of the web. The repair system or method begins when a rail defect is identified and located, such as by using an ultrasonic rail-testing car. The ultrasonic rail-testing car can precisely locate and

filler weld processes. The preferred geometries are a beveled bottom or a double J (i.e., opposed J shapes) shaped bottom.

[00052] Because only the top portion of the rail 10 is removed, that portion corresponding to the material of the slot 28 there is no change in the length of the rail and the ART remains unaffected. Because of the clamping action of the apparatus and the fact that only the top portion of the rail is removed, there is no need to accurately align the rail heads. The rail head is held in perfect alignment by the lower portion of the rail which has not been removed for replacement.

[00053] Containment shoes or molds 30, 32 are put in place around the void or slot 28 created by removal of the top portion of the rail. The bottom and remaining sides of the rail encompassing the void or slot 28 are preheated. The high carbon content filler metal welding element of the rail apparatus is then used to perform a filler metal weld, which fills the void created by the removal of the top portion of the rail. The containment shoes keep the molten metal from running out of the void and act to control the temperature of the filler metal weld.

[00054] Because the repair is accomplished without using a rail plug, there is no need to transport rail plugs to or away from the repair site. Additionally, the ART of the original rail is maintained as no additional rail or weld materials are or even can be added or removed from the existing rail. Because only a single weld needs to be made, no rail in the form of rail plugs needs to be removed and subsequently replaced and no anchors need to be removed and subsequently replaced, whereas prior methods required two welds, the repair method is faster than any prior repair methods. Given that the repair method is faster and does not require additional

0.1% and 1.0% by weight. By comparison, rail steel has a carbon content of about .84%. Appropriate alloying elements are also used in the weld rod or electrode. In general the weld electrode with the above carbon content and selected alloying can produce a weld with adequate bulk hardness and essentially stop migration of carbon from the rail.

[00059] Hydrogen embrittlement can cause steel to lose ductibility and impact values and in general degrades mechanical properties. Hydrogen embrittlement is to be avoided. Using GMAW with inert gas shielding protects the weld pool from atmospheric hydrogen. The solid electrode can be treated for removal of hydrogen.

[00060] The GMAW using inert gas shielding, a solid weld rod with the composition in the correct range and which has been treated for hydrogen removal is desirable.

[00061] In terms of welding, the shape of the bottom of the groove or weld root can be important, particularly on the first welding pass. The root is formed at the bottom of the groove and between the sides of the groove. The root can be beveled or double J-shaped.

[00062] The method taught here could be accomplished using the teachings, and in the alternative embodiment, void 28 could be filled by applying a thermite crucible and thermite method using shoes 30, 32 to contain the molten steel using thermite techniques. Other methods can be used to fill the removed section. These methods may be acceptable to a particular railroad depending upon their requirements. For example, a welding process known as the electroslag process (

be deep enough to eliminate the defect. The WMU can then be removed from the rail. A Weld Containment Device (WCD) as shown in Patent No. 6,396,020 is centered around the slot, attached to the rail and clamped in to place. A Weld Delivery Unit containing the welding torch and manipulator can be clamped to the rail. The WDU is also shown in 6,396,020. The WDU is aligned with the slot or void. The slot or void can then be preheated to the proper weld interpass temperature with an induction heating torch or an oxy-propane torch. The preheating torch is removed and the weld program is initiated.

[00065] Initially the weld is purged with shielding gas which is desirably a mixture of 85% argon and 15% carbon dioxide. A solid weld electrode having the following composition was used: 0.1% to 1.0% carbon, 1.8-2.0% manganese, .30-.40% molybdenum, 0.5%-0.6% nickel, 0.5% to 0.95% silicon and the balance being iron and trace elements. The welding arc is initiated and the weld progresses with several uninterrupted passes. The number of passes will vary depending on the depth of the machining. About 4-18 passes can be used to fill a 0.875 inch deep groove which is one inch wide. The welding voltage is about 25 - 42V. The wire feed speed is about 150-250 inches per minute (ipm). The travel speed is ranges between 5 and 30 ipm. The resulting amperage is between 140 and 400 amps. A weave is used to improve penetration and tie-in. After the weld has been essentially completed, a post purge is used to shield the molten metal until it is solidified. The WDU is removed from the rail. The WCD is removed from the rail. The weld can then be finish ground to match the contour of the rail. U.S. Patent 6,396,020 is incorporated by reference as if fully set forth herein.

susceptibility trends, not to provide quantification of specific materials. The experience with rail welds described herein is believed consistent.

[00069] Recent tests show that an optimum chemistry in a welding electrode which produces a deposit of 0.1% to 1.0% carbon, 1.8 to 2.0% manganese, 0.3 to 0.4% molybdenum, 0.5 to 0.6% nickel and 0.5 to 0.95% silicon, the balance of the alloy comprising iron, will resist the loss of carbon in the rail material and also have a weld material which will itself have adequate tensile strength.

[00070] The alloying materials should be present in the electrode itself, in higher proportions to account for loss in the welding operation as the plasma formed by welding causes disassociation of the materials. Thus in the electrode, the carbon should be a percentage as high as about 1.1% in a solid electrode to about 1.2 % in a cored or composite electrode.

[00071] A difficulty in the use of this solid electrode is the difficulty in forming the rod in the first instance. Alloy, heat and forming processes all modify the material. Thus, the simple drawing of steel having a beginning alloy content in the proportions described above will result in a work hardening that prevents formation in the desired dimensions because of the brittleness imparted thereby. The annealing of the material will, in the ordinary instance, result in migration of a proportion of the carbon to the surface of the material, thereby resulting in a net loss of carbon from the surface as a result of the use of the material.

[00072] The forming of appropriate electrode of a desired dimension, such as 0.0625 inches is accomplished by a series of steps as shown in Fig 9. An

defined by the walls of the tube. Relative dimensions are such that the particles 134 comprise a mixture of materials having the requisite composition to result in the finished electrode having the percentages described above, for example about 1.2% carbon, which when combined with the mild steel walls of the electrode during the welding operation will result in the desired concentration, within the ranges discussed above.

[00075] While the concepts of the present disclosure have been illustrated and described in detail in the drawings and foregoing description, such an illustration and description is to be considered as exemplary and not restrictive in character, it being understood that only the illustrative embodiments have been shown and described and that all changes and modifications that come within the spirit of the disclosure are desired and protected.

[00076] There are a plurality of advantages that may be inferred from the present disclosure arising from the various features of the apparatus, systems and methods described herein. It will be noted that alternative embodiments of each of the apparatus, systems, and methods of the present disclosure may not include all of the features described yet still benefit from at least some of the inferred advantages of such features. Those of ordinary skill in the art may readily devise their own implementations of an apparatus, system, and method that incorporate one or more of the features of the present disclosure and fall within the spirit and scope of the invention as defined by the appended claims.